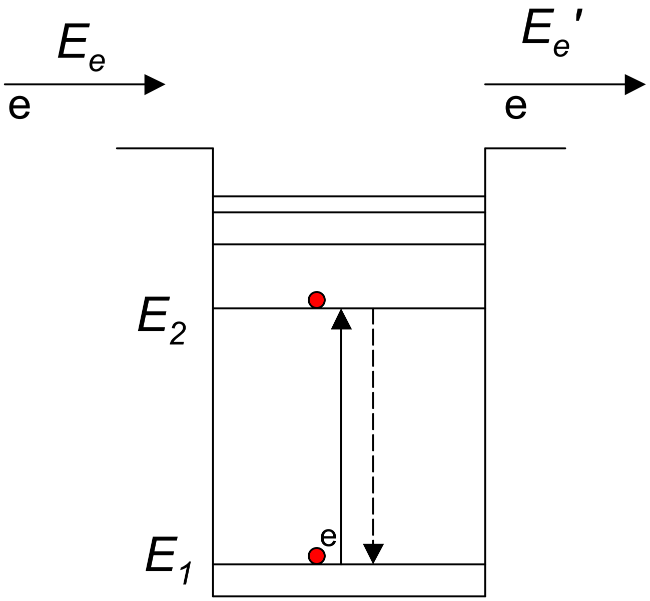
Franck-Hertz Experiment

- Franck and Hertz wanted to show that energy transitions in an atom were quantized.
- They believed that electron's in a beam should transfer their energy to a gas in quantized steps.



Conservation of Energy

$$E_e + E_1 = E_e^{/} + E_2 \quad \rightarrow \quad E_e - E_e^{/} = \left(E_2 - E_1\right) = \Delta E_{21}$$

Hydrogen - like Atoms

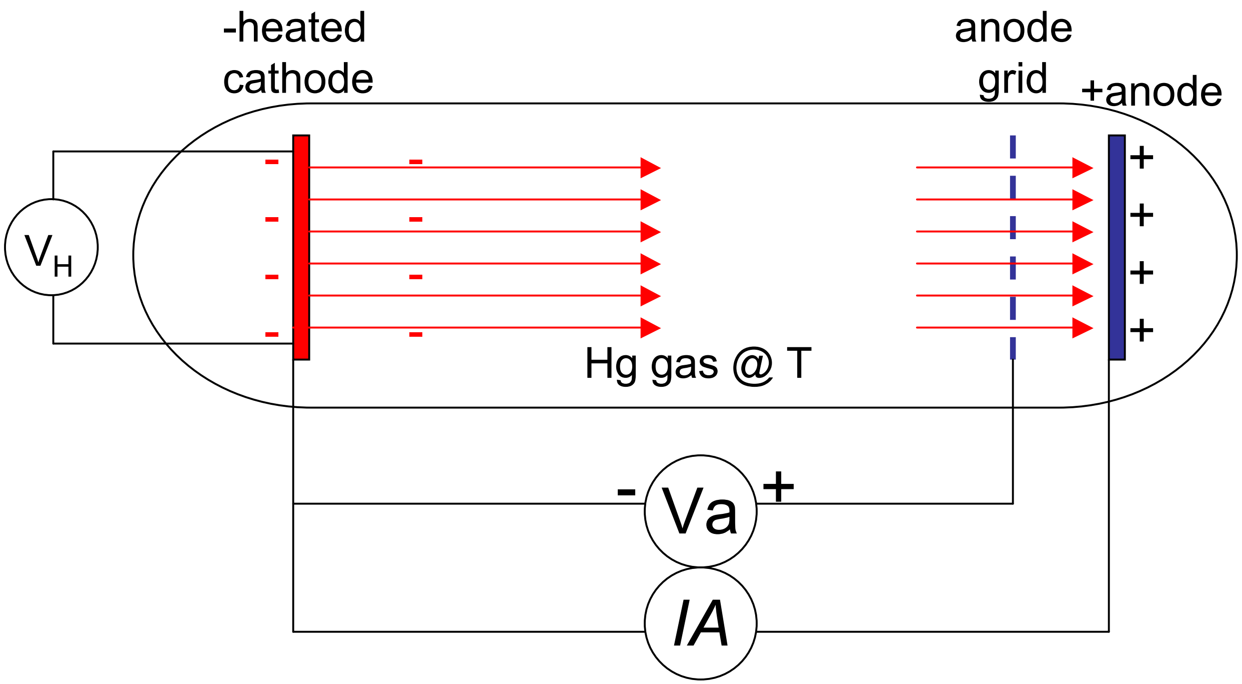
$$E_n = -13.6\frac{Z^2}{n^2}\ eV \qquad E_{n=1}^{Hg} = -10.38\ eV$$

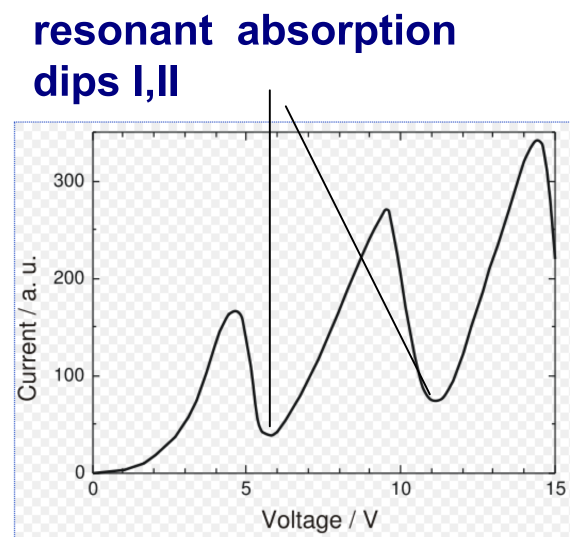
$\mathbf{Hg}_{80}^{201}$ **Atom** *Ground State* $(\mathrm{Xe})^{54}\ 4\mathrm{f}^{14}\, 5\mathrm{d}^{10}\, 6\mathrm{s}^{2}$

Na_{11}^{23} **Atom** *Ground State* $1\mathrm{s}^2\, 2\mathrm{s}^2\, 2\mathrm{p}^6\, 3s^1$

- Monatomic Hg, Ne, Ar are used so not to excite molecular transitions eg. N2, O2, etc.

Franck-Hertz Tube





- V_H supplies current to the heated cathode creating electrons by thermionic emission.
- Electrons are accelerated to the anode by adjusting Va = 0 = 80V eg.
- Electrons reaching the anode grid are collected and establish an anode grid current *IA.*
- Some electrons colliide with Hg atoms and transfer energy e + Hg --> e' + Hg* (*excited).

  $Ee + E_{Hg} = Ee' + E_{Hg^*}$ $Ee = \Delta(E_{hg^*} - E_{hg})$
- e' losses energy and stops accelerating, a drop in *IA* occurs creating an **absorption dip**.
- e' re-accelerates and can collide with another Hg atoms, again e + Hg --> e' + Hg*
  and a second absorption dip occurs.
- $\Delta(E_{hg^*} - E_{hg})$ represents a quantized energy transition in Hg!

$_{80}$Hg **Ground State** (Xe) $4f^{14}\,5d^{10}\,6s^{2}\;\;6p..$

$L = 0 \quad and \quad S = \tfrac{1}{2} + \tfrac{1}{2} = 1\,,\,0$

$J = L + S = \;0 + 1 = 1 \qquad {}^{2S+1}L_J \;=\; {}^{3}S_1 \quad \textit{not allowed}$

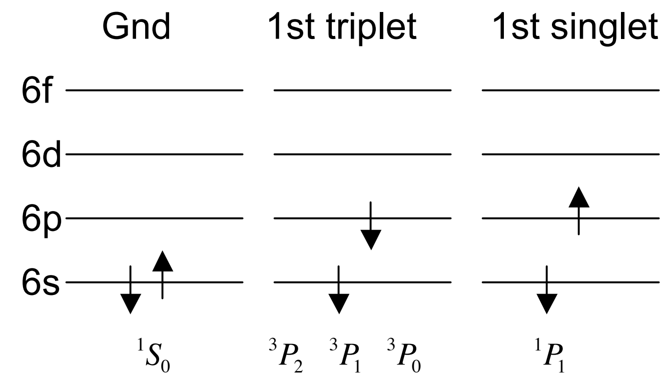
$J = L + S = \;0 + 0 = 0 \qquad {}^{2S+1}L_J \;=\; {}^{1}S_0 \quad \textit{ground state}$

1st Excited State (Xe) $4f^{14}\,5d^{10}\,6s^{1}\;\;6p^{1}$

$L = 0 + 1 = 1 \quad and \quad S = \tfrac{1}{2} + \tfrac{1}{2} = 1\,,\,0$

$J = L + S = \;1 + 1 = 2,1,0 \qquad {}^{2S+1}L_J \;=\; {}^{3}P_2\,,{}^{3}P_1\,,\,{}^{3}P_0$

$J = L + S = \;1 + 0 = 1 \qquad {}^{2S+1}L_J \;=\; {}^{1}P_1$

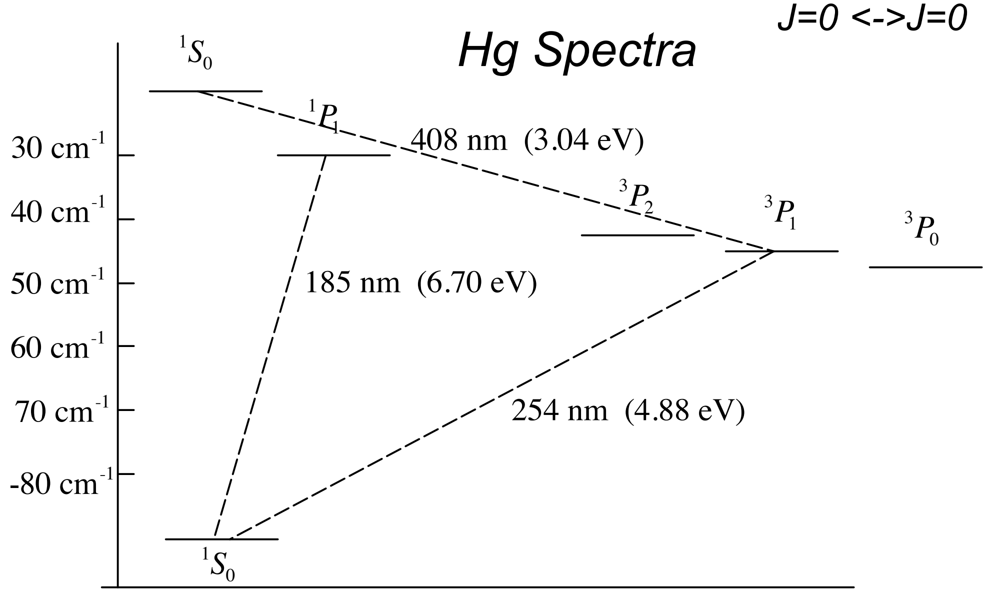


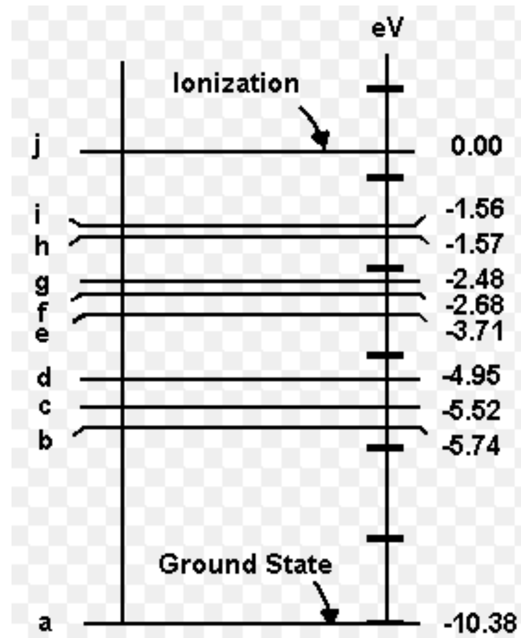
Electric Dipole Transitions

ΔL=1 Δm$_L$=0,+-1

ΔJ=0,+-1

J=0 <->J=0 not allowed





A few energy levels for the mercury atom